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**Yoshida et al.**

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(54) **APPARATUS AND METHOD FOR PERFORMING EFFICIENT RETRANSMISSION**

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***H04W 56/00*** (2009.01)

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CPC ..... ***H04W 56/00*** (2013.01)

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CPC .... H04W 56/00; H04L 1/1835; H04L 1/1874
USPC ..... 455/502, 517, 69, 70; 370/324, 390, 370/394
See application file for complete search history.

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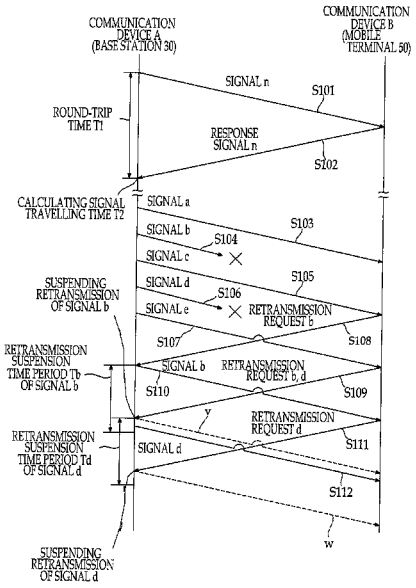
(57) **ABSTRACT**

A communication device calculates a signal travelling time indicating a time period from a first time at which the signal has been transmitted from the communication device, to a second time at which the transmitted signal is expected to arrive at another communication device serving as a communication partner. The communication device retransmits the signal to the another communication device when a retransmission request of the signal is received from the another communication device after the signal has been transmitted to the another communication device, and suspends a retransmission of the signal when the retransmission request is received again from the another communication device before the signal travelling time elapses from the first time.

**6 Claims, 11 Drawing Sheets**



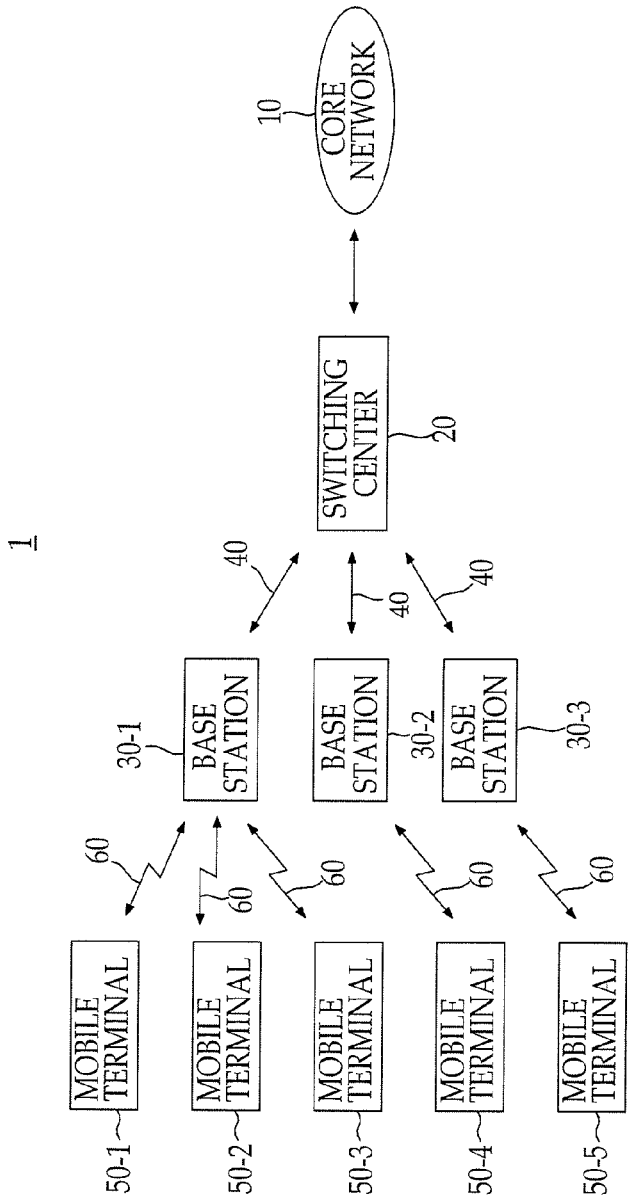

1
10
CORE NETWORK
SWITCHING CENTER
20
40
40
40
30-1
BASE STATION
BASE STATION
30-2
BASE STATION
30-3
60
60
60
60
60
60
MOBILE TERMINAL
50-1
MOBILE TERMINAL
50-2
MOBILE TERMINAL
50-3
MOBILE TERMINAL
50-4
MOBILE TERMINAL
50-5

FIG. 1A

FIG. 1B

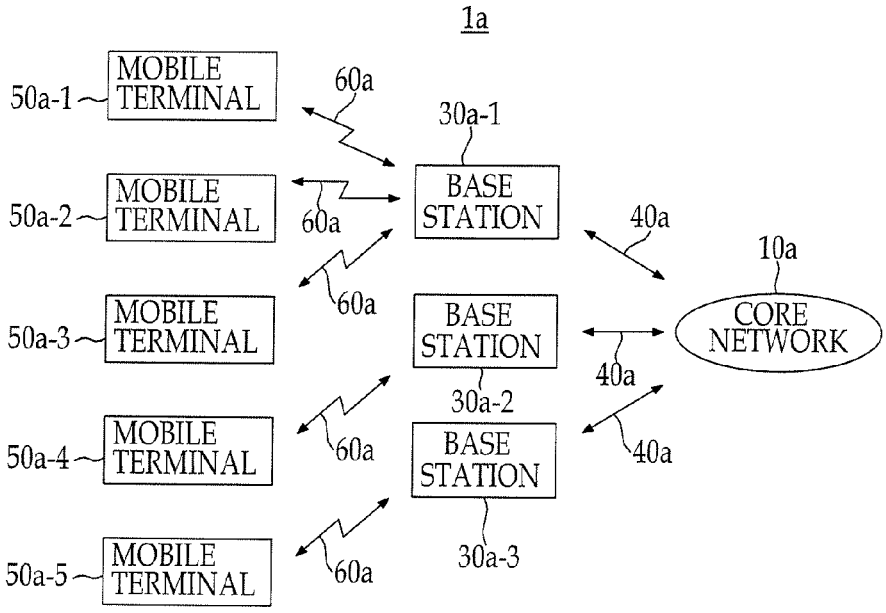

1a
MOBILE TERMINAL
50a-1
MOBILE TERMINAL
50a-2
MOBILE TERMINAL
50a-3
MOBILE TERMINAL
50a-4
MOBILE TERMINAL
50a-5
60a
60a
60a
60a
60a
30a-1
BASE STATION
30a-2
BASE STATION
30a-3
BASE STATION
40a
40a
40a
10a
CORE NETWORK

FIG. 2

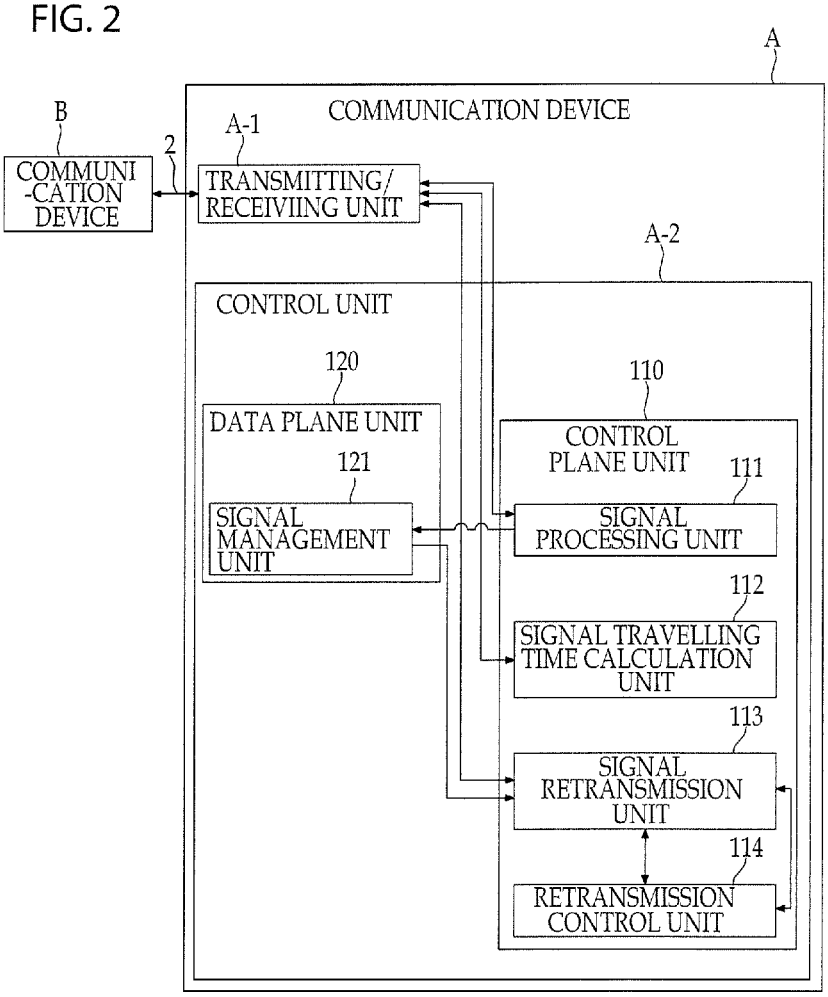

A
COMMUNICATION DEVICE
B
COMMUNI-CATION DEVICE
2
A-1
TRANSMITTING/ RECEIVIING UNIT
A-2
CONTROL UNIT
120
DATA PLANE UNIT
121
SIGNAL MANAGEMENT UNIT
110
CONTROL PLANE UNIT
111
SIGNAL PROCESSING UNIT
112
SIGNAL TRAVELLING TIME CALCULATION UNIT
113
SIGNAL RETRANSMISSION UNIT
114
RETRANSMISSION CONTROL UNIT

FIG. 3

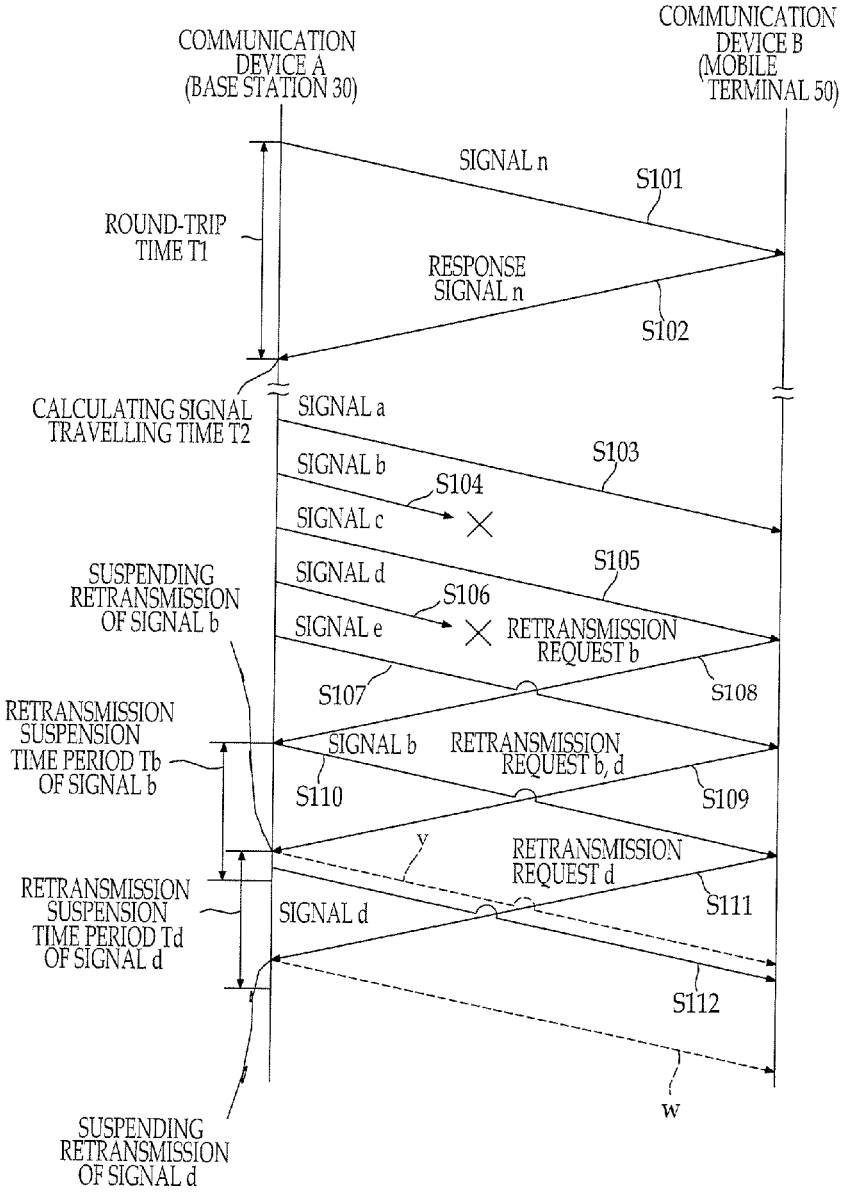

COMMUNICATION DEVICE A (BASE STATION 30)
COMMUNICATION DEVICE B (MOBILE TERMINAL 50)
SIGNAL n
S101
ROUND-TRIP TIME T1
RESPONSE SIGNAL n
S102
CALCULATING SIGNAL TRAVELLING TIME T2
SIGNAL a
SIGNAL b
S103
S104
SIGNAL c
S105
SUSPENDING RETRANSMISSION OF SIGNAL b
SIGNAL d
S106
SIGNAL e
RETRANSMISSION REQUEST b
S107
S108
RETRANSMISSION SUSPENSION TIME PERIOD Tb OF SIGNAL b
SIGNAL b
RETRANSMISSION REQUEST b, d
S110
S109
y
RETRANSMISSION REQUEST d
RETRANSMISSION SUSPENSION TIME PERIOD Td OF SIGNAL d
SIGNAL d
S111
S112
w
SUSPENDING RETRANSMISSION OF SIGNAL d

FIG. 4A

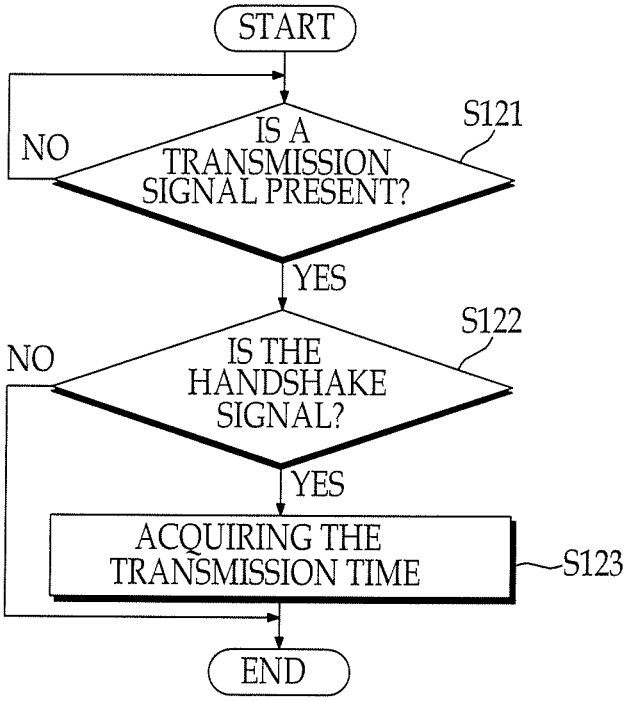

START
S121
IS A TRANSMISSION SIGNAL PRESENT?
NO
YES
S122
IS THE HANDSHAKE SIGNAL?
NO
YES
ACQUIRING THE TRANSMISSION TIME
S123
END

FIG. 4B

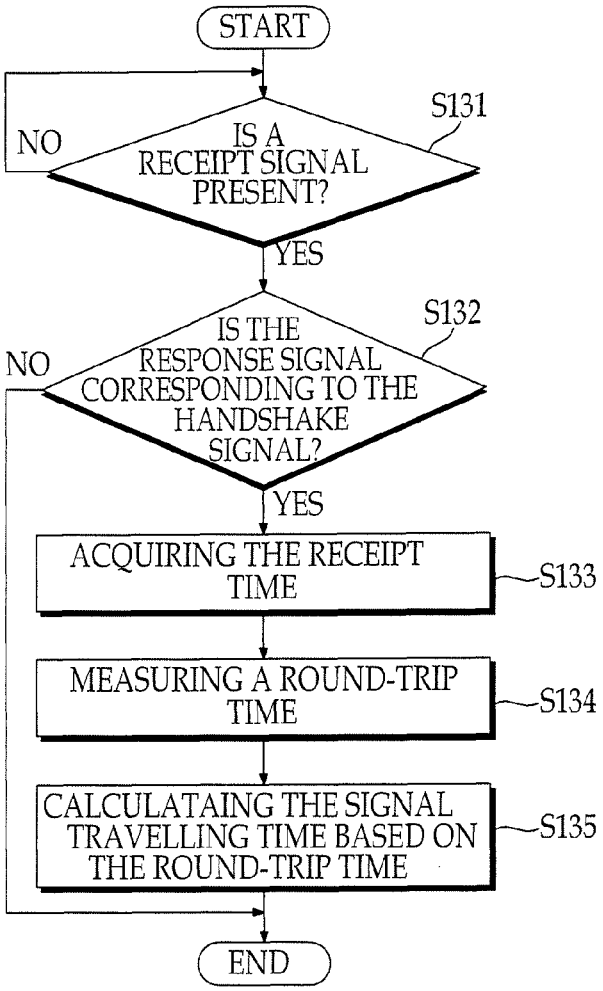

START
S131
NO
IS A RECEIPT SIGNAL PRESENT?
YES
S132
IS THE RESPONSE SIGNAL CORRESPONDING TO THE HANDSHAKE SIGNAL?
NO
YES
ACQUIRING THE RECEIPT TIME
S133
MEASURING A ROUND-TRIP TIME
S134
CALCULATAING THE SIGNAL TRAVELLING TIME BASED ON THE ROUND-TRIP TIME
S135
END

FIG. 5

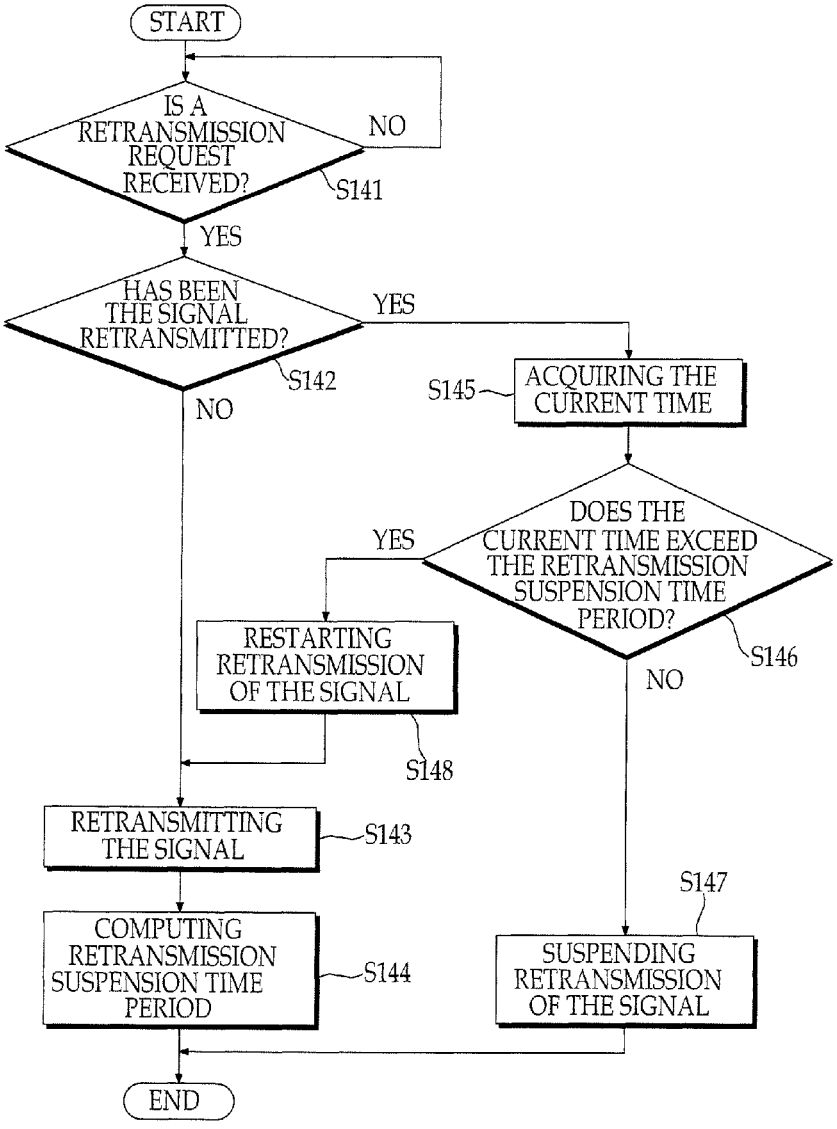

START
IS A RETRANSMISSION REQUEST RECEIVED?
NO
S141
YES
HAS BEEN THE SIGNAL RETRANSMITTED?
YES
S142
NO
S145
ACQUIRING THE CURRENT TIME
DOES THE CURRENT TIME EXCEED THE RETRANSMISSION SUSPENSION TIME PERIOD?
YES
S146
NO
RESTARTING RETRANSMISSION OF THE SIGNAL
S148
RETRANSMITTING THE SIGNAL
S143
COMPUTING RETRANSMISSION SUSPENSION TIME PERIOD
S144
S147
SUSPENDING RETRANSMISSION OF THE SIGNAL
END

FIG. 6

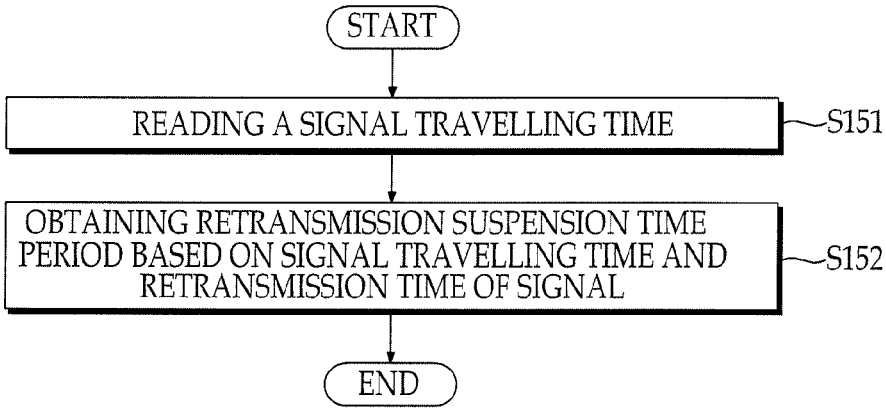

START
READING A SIGNAL TRAVELLING TIME
S151
OBTAINING RETRANSMISSION SUSPENSION TIME PERIOD BASED ON SIGNAL TRAVELLING TIME AND RETRANSMISSION TIME OF SIGNAL
S152
END

FIG. 7

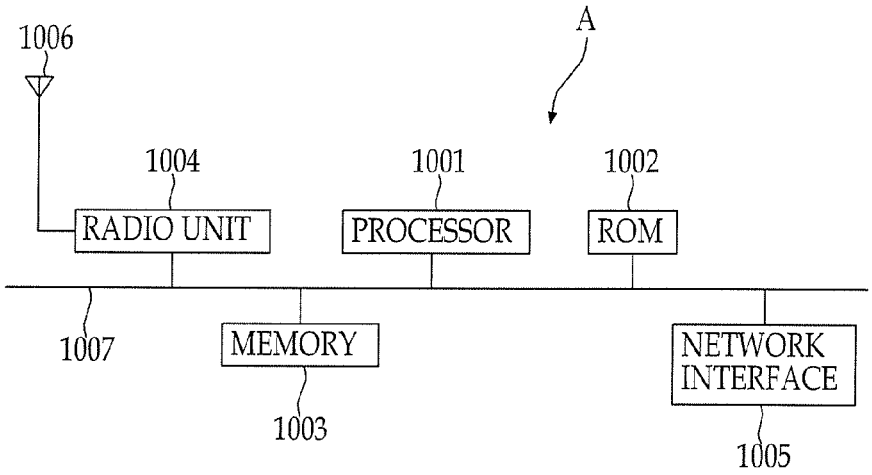

1006
A
1004
1001
1002
RADIO UNIT
PROCESSOR
ROM
1007
MEMORY
1003
NETWORK INTERFACE
1005

FIG. 8

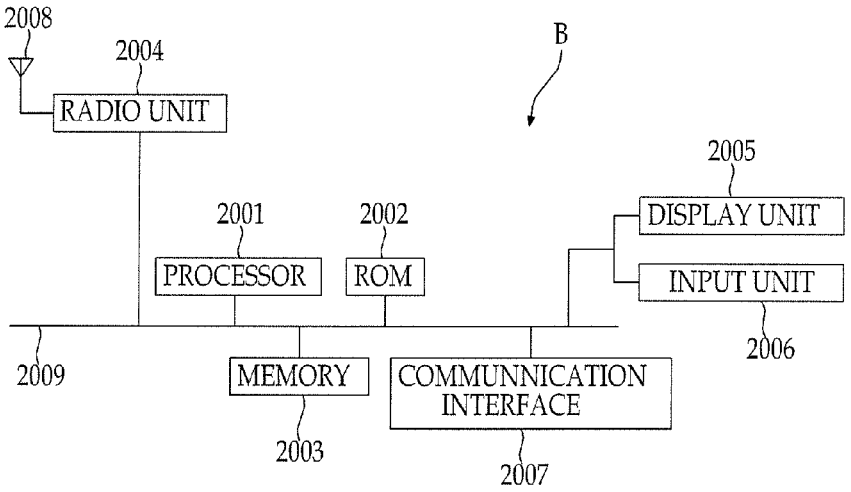
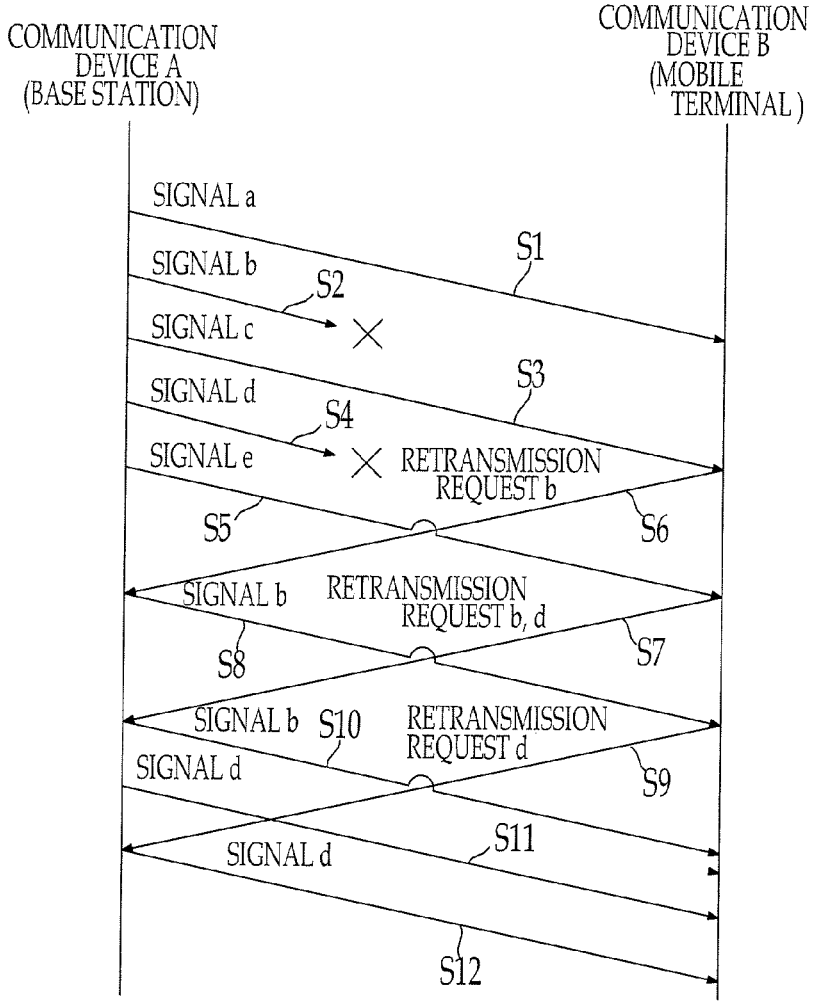

2008
2004
RADIO UNIT
B
2005
DISPLAY UNIT
2001
PROCESSOR
2002
ROM
INPUT UNIT
2006
2009
MEMORY
COMMUNNICATION INTERFACE
2003
2007

FIG. 9


COMMUNICATION DEVICE A (BASE STATION)
COMMUNICATION DEVICE B (MOBILE TERMINAL)
SIGNAL a
S1
SIGNAL b
S2
SIGNAL c
S3
SIGNAL d
S4
SIGNAL e
RETRANSMISSION REQUEST b
S5
S6
SIGNAL b
RETRANSMISSION REQUEST b, d
S8
S7
SIGNAL b
S10
RETRANSMISSION REQUEST d
SIGNAL d
S9
S11
SIGNAL d
S12

# APPARATUS AND METHOD FOR PERFORMING EFFICIENT RETRANSMISSION

## CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority from the prior Japanese Patent Application No. 2012-239609, filed on Oct. 30, 2012, the entire contents of which are incorporated herein by reference.

## FIELD

The present disclosure relates to apparatus and method for performing efficient retransmission.

## BACKGROUND

There has been a known technology in which when a communication device of a calling party transmitting a signal to a communication device of a communication partner receives a retransmission request of signal from the communication device of the communication partner, the communication device of the calling party upon receiving the retransmission request retransmits the signal to the communication device of the communication partner. Hereinafter, the communication device of the calling party which transmits a signal to the communication device of the communication partner is referred to as a "communication device A". Also, the communication device of the communication partner which transmits the retransmission request of signal to the communication device A is referred to as a "communication device B"

Related techniques are disclosed in, for example, Japanese Laid-Open Patent Publication No. 2007-150859, Japanese Laid-Open Patent Publication No. 2008-219408, and International Publication No. WO 2004/107639.

In the related art, however, there is a concern that the communication speed between the communication devices may be reduced due to the retransmission of signals by the communication device that received the retransmission request.

FIG. **9** is a diagram illustrating an example of a retransmission issue of signal in the related art. In the example of FIG. **9**, the communication device A is a base station and the communication device B is a mobile terminal. FIG. **9** illustrates the state of the communication between the communication device A and the communication device B in a chronological order. Further, the details of the state of the communication illustrated in FIG. **9** are described in Chapter 11.5.2. of GPP TS 25.322 V10.1.0.

First, the communication device A transmits signal "a" having a sequence number of 0 (zero) to the communication device B (step S**1**). It is assumed that the signal "a" arrives at the communication device B. Subsequently, the communication device A transmits signal "b" having a sequence number of 1 (one) to the communication device B (step S**2**). It is assumed that the signal "b" does not arrive at the communication device B. Subsequently, the communication device A transmits signal "c" having a sequence number of 2 (two) to the communication device B (step S**3**). It is assumed that the signal "c" arrives at the communication device B. Subsequently, the communication device A transmits signal "d" having a sequence number of 3 (three) to the communication device B (step S**4**). It is assumed that the signal "d" does not arrive at the communication device B. Subsequently, the communication device A transmits signal "e" having a sequence number of 4 (four) to the communication device B (step S**5**). It is assumed that the signal "e" arrives at the communication device B.



In the meantime, the communication device B which has received the signal "c" detects that the signal "b" has been missed and transmits a retransmission request of the signal "b" to the communication device A (step S**6**). The communication device B which has received the signal "e" has not yet received the signal "b" and signal "d". Therefore, the communication device B detects that the signal "b" and signal "d" are missed and transmits a retransmission request of the signal "b" and a retransmission request of the signal "d" to the communication device A (step S**7**).

The communication device A which has received the retransmission request of the signal "b" transmitted at step S**6** retransmits the signal "b" to the communication device B (step S**8**). It is assumed that the signal "b" arrives at the communication device B. The communication device B which has received the signal "b" has not yet received the signal "d". Therefore, the communication device B detects that the signal "d" is missed and transmits a retransmission request of the signal "d" to the communication device A (step S**9**). In the meantime, since the communication device A which has received the retransmission request "b" and the retransmission request "d" transmitted at step S**7** has received the retransmission request of the signal "b" again although the communication device A has retransmitted the signal "b" at step S**8**, the communication device A retransmits the signal "b" to the communication device B (step S**10**). The communication device A retransmits the signal "d" after the retransmission of the signal "b" at step S**10** (step S**11**). In the meantime, since the communication device A which has received the retransmission request of the signal "d" transmitted at step S**9** has received the retransmission request of the signal "b" again although the communication device A has retransmitted the signal "d" at step S**11**, the communication device A retransmits the signal "d" to the communication device B (step S**12**).

## SUMMARY

According to one aspect of the present disclosure, there is provided a communication device. The communication device calculates a signal travelling time indicating a time period from a first time at which the signal has been transmitted from the communication device, to a second time at which the transmitted signal is expected to arrive at another communication device serving as a communication partner. The communication device retransmits the signal to the another communication device when a retransmission request of the signal is received from the another communication device after the signal has been transmitted to the another communication device, and suspends a retransmission of the signal when the retransmission request is received again from the another communication device before the signal travelling time elapses from the first time.

The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims. It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention, as claimed.

## BRIEF DESCRIPTION OF DRAWINGS

FIG. **1**A is a diagram illustrating an example of an entire configuration of a network including a communication device, according to an embodiment.

FIG. **1**B is a diagram illustrating an example of an entire configuration of a network including a communication device, according to a embodiment.

FIG. **2** is a diagram illustrating an example of a configuration of a communication device A and a communication device B, according to an embodiment.

FIG. **3** is a signal sequence chart illustrating an example of states of communications of a communication device A and a communication device B, according to an embodiment.

FIG. **4**A is a diagram illustrating an example of an operational flowchart for calculating a signal travelling time by a communication device, according to an embodiment.

FIG. **4**B is a diagram illustrating an example of an operational flowchart for calculating a signal travelling time by a communication device, according to an embodiment.

FIG. **5** is a diagram illustrating an example of an operational flowchart for retransmitting of signal by a communication device, according to an embodiment.

FIG. **6** is a diagram illustrating an example of an operational flowchart for computing a retransmission suspension time period, according to an embodiment.

FIG. **7** is a diagram illustrating an exemplary hardware configuration of a communication device, according to an embodiment.

FIG. **8** is a diagram illustrating an exemplary hardware configuration of a communication device, according to an embodiment.

FIG. **9** is a signal sequence chart illustrating a retransmission issue of signal in the related art.

## DESCRIPTION OF EMBODIMENTS

As can be seen from FIG. **9**, since the communication device A retransmits the signal "b" at step S**8** and also retransmits the signal "d" at step S**11**, retransmission of the signal "b" at step S**10** and retransmission of the signal "d" at step S**12** may not be performed. Nevertheless, since an amount of data in a communication path between the communication devices increases due to the retransmission of the signal "b" at step S**10** and the retransmission of the signal "d" at step S**12** by the communication device A, there is a concern that a communication overhead between the communication devices may increase.

The disclosed technology has been made in an effort to solve the problems and intends to provide a communication device and a communication method capable of reducing the communication overhead between the communication devices due to the retransmission of signals.

In the following, embodiments of a communication device and a communication method disclosed herein will be described with reference to the accompanying drawings. Further, a technology disclosed herein is not limited to the embodiments.

FIG. **1**A is a diagram illustrating an example of an entire configuration of a network including a communication device, according to an embodiment. The network **1** is a network over which communication is performed based on, for example, the 3G (3rd Generation) communication standard. The network **1** includes a switching center **20** connected to a core network **10**. Further, the network **1** includes base stations **30-1**, **30-2**, **30-3** connected to the switching center **20** through a communication link **40**. Further, the network **1** includes mobile terminals **50-1**, **50-2**, **50-3** connected to the base station **30-1** through a radio link **60**. Further, the network **1** includes a mobile terminal **50-4** connected to the base station **30-2** through the radio link **60** and a mobile terminal **50-5** connected to the base station **30-3** through the radio link **60**. Further, the number of the base stations **30** connected to the switching center **20** or the number of the mobile terminals **50** connected to the base station **30** is not particularly limited.

The communication device of a calling party transmits and receives a signal to and from the communication device of the communication partner through at least one of the communication link **40** and the radio link **60** (hereinafter, appropriately referred to as "communication path **2**"). Accordingly, in the present embodiment, any one of the switching center **20**, the base station **30** and the mobile terminal **50** may be the communication device. For example, when it is assumed that the mobile terminal **50** is a communication device A transmitting a signal to the communication device of the communication partner, the base station **30** or the switching center **20** becomes a communication device B of the communication partner transmitting a retransmission request to the mobile terminal **50**. Further, when it is assumed that the base station **30** is the communication device A transmitting a signal to the communication device of the communication partner, the switching center **20** or the mobile terminal **50** becomes the communication device B of the communication partner transmitting the retransmission request to the base station **30**. Further, when it is assumed that the switching center **20** is the communication device A transmitting a signal to the communication device of the communication partner, the base station **30** or the mobile terminal **50** becomes the communication device B of the communication partner transmitting the retransmission request to the switching center **20**.

FIG. **1**B is a diagram illustrating an example of an entire configuration of a network including a communication device, according to an embodiment. The network **1***a* is a network over which a communication is performed based on, for example, the LTE (Long Term Evolution) communication standard. The network **1***a* includes base stations **30***a*-**1**, **30***a*-**2**, **30***a*-**3** connected to a core network **10***a* through communication links **40***a*. Further, the network **1***a* includes mobile terminals **50***a*-**1**, **50***a*-**2**, **50***a*-**3** connected to the base station **30***a*-**1** through radio links **60***a*. Further, the network **1***a* includes a mobile terminal **50***a*-**4** connected to the base station **30***a*-**2** through a radio link **60***a* and a mobile terminal **50***a*-**5** connected to the base station **30***a*-**3** through a radio link **60***a*. Further, the number of base stations **30***a* connected to the core network **10***a* or the number of mobile terminals **50***a* connected to the base station **30***a* is not particularly limited.

The communication device of the calling party transmits and receives a signal to and from a communication device of a communication partner through at least one of the communication link **40***a* and the radio link **60***a* (hereinafter, appropriately referred to as "communication path **2**"). Accordingly, in the embodiment, any one of the base station **30***a* and the mobile terminal **50** may be the communication device. For example, when it is assumed that the mobile terminal **50***a* is the communication device A transmitting a signal to the communication device of the communication partner, the base station **30** becomes the communication device B of the communication partner transmitting the retransmission request to the mobile terminal **50***a*. Further, when it is assumed that the base station **30***a* is the communication device A transmitting a signal to the communication device of the communication partner, the mobile terminal **50***a* becomes the communication device B of the communication partner transmitting the retransmission request to the base station **30***a*.

FIG. **2** is a diagram illustrating a configuration example of a communication device A and a communication device B, according to an embodiment. Further, since the communication device A and the communication device B have the same configuration and thus, the description of the configuration of

the communication device B is omitted and only the configuration of the communication device A will be described.

As illustrated in FIG. **2**, a communication device A according to an embodiment includes a transmitting/receiving unit A-**1** and a control unit A-**2**. Further, the control unit A-**2** includes a control plane unit **110** and a data plane unit **120**. The control plane unit **110** includes a signal processing unit **111**, a signal travelling time calculation unit **112**, a signal retransmission unit **113**, and a retransmission control unit **114**. Further, the data plane unit **120** includes a signal management unit **121**.

The transmitting/receiving unit A-**1** transmits and receives a signal to and from the communication device B. The transmitting/receiving unit A-**1** receives a signal to be transmitted to the communication device B from the signal processing unit **111**. The transmitting/receiving unit A-**1** transmits the signal received from the signal processing unit **111** to the communication device B through the communication path **2**. Hereinafter, a signal transmitted to the communication device B by the signal transmitting/receiving unit A-**1** is referred to as appropriately "transmission signal".

Further, the transmitting/receiving unit A-**1** receives a signal to be retransmitted to the communication device B from the signal retransmission unit **113**. The transmitting/receiving unit A-**1** transmits the signal received from the signal retransmission unit **111** to the communication device B through the communication path **2**.

Further, the transmitting/receiving unit A-**1** receives a signal from the communication device B through the communication path **2**. Hereinafter, the signal received by transmitting/receiving unit A-**1** from the communication device B is referred to as appropriately "receipt signal". The transmitting/receiving unit A-**1** receives a response signal returned from the communication device B as a receipt signal in response to the transmission signal from the communication device A. The response signal is a signal to confirm that the transmission signal has arrived at the communication device B, and is also called ACK (ACKnowledgement). The transmitting/receiving unit A-**1** outputs the response signal received from the communication device B to the signal processing unit **111**.

Further, the transmitting/receiving unit A-**1** receives the retransmission request of signal from the communication device B as a receipt signal. The retransmission request is also called NACK (Negative ACKnowledgement). The transmitting/receiving unit A-**1** outputs the retransmission request received from the communication device B to the signal retransmission unit **113**.

The signal processing unit **111** produces a transmission signal. For example, when the communication device A is the base station **30**, **30***a* or the switching center, the signal processing unit **111** performs a protocol conversion for data packets received from a higher level device to produce the transmission signal. Further, for example, when the communication device A is the mobile terminal **50** or the mobile terminal **50***a*, the signal processing unit **111** performs a protocol conversion for, for example, voice data, input from a user to produce the transmission signal. The signal processing unit **111** outputs the produced transmission signal to the transmitting/receiving unit A-**1** and the signal management unit **121**.

Further, the signal processing unit **111** receives an input of a response signal from the transmitting/receiving unit A-**1**. The signal processing unit **111** deletes information of the transmission signal of which delivery is confirmed by the response signal from the signal management unit **121**.

The signal management unit **121** receives an input of the transmission signal from the signal processing unit **111**. The signal management unit **121** stores and accumulates the received transmission signal for each sequence number of the transmission signal. Further, the transmission signal accumulated in the signal management unit **121** is reduced with being deleted by the signal processing unit **111**.

The signal travelling time calculation unit **112** determines a signal travelling time which corresponds to a time period between a first time at which the signal is transmitted from the communication device A to the communication device B and a second time at which the signal arrives (being expected to arrive) at the communication device B. For example, the signal travelling time calculation unit **112** calculates the signal travelling time based on a time period between the first time at which a transmission signal is transmitted by the transmitting/receiving unit A-**1** to the communication device B and a third time at which a response signal is returned from the communication device B in response to the signal transmitted from the transmitting/receiving unit A-**1**. For example, the signal travelling time calculation unit **112** calculates the signal travelling time each time when a predetermined period of time comes. The signal travelling time calculated by the signal travelling time calculation unit **112** is held in the signal travelling time calculation unit **112** until a next signal travelling time is calculated. Further, the details of a process of calculating the signal travelling time by the signal travelling time calculation unit **112** will be described later.

The signal retransmission unit **113** receives an input of the retransmission request from the transmitting/receiving unit A-**1**. Upon receipt of the retransmission request, the signal retransmission unit **113** retransmits the signal to the communication device B through the transmitting/receiving unit A-**1**. For example, the signal retransmission unit **113** acquires the transmission signal corresponding to a sequence number specified by the retransmission request from the signal management unit **121** and retransmits the acquired transmission signal to the communication device B through the transmitting/receiving unit A-**1**. Further, when the signal is retransmitted, the signal retransmission unit **113** notifies the retransmission control unit **114** that the signal is retransmitted.

Upon receipt of the retransmission request again from the communication device B in a period of time before a signal travelling time elapses after retransmitting the signal to the communication device B, the retransmission control unit **114** suspends the retransmission of the signal. Specifically, when the signal is retransmitted from the signal retransmission unit **113** which has received the retransmission request, the retransmission control unit **114** accesses the signal travelling time calculation unit **112** to read the signal travelling time. The retransmission control unit **114** adds the signal travelling time read and a time at which the signal was retransmitted, to obtain a retransmission suspension time period during which the retransmission of signal is to be suspended. That is, the retransmission suspension time period indicates a time period from a first time at which the communication device A has retransmitted the signal to the communication device B, to a second time at which the signal travelling time elapses from the first time. When the signal retransmission unit **113** receives the retransmission request again at a time not exceeding the retransmission suspension time period, the retransmission control unit **114** sends a command to suspend the retransmission of signal to the signal retransmission unit **113**.

Further, upon receipt of the retransmission request again from the communication device B after the signal travelling time has elapsed from a time at which the signal was retransmitted to the communication device B, the retransmission

control unit **114** restarts the retransmission of the signal. Specifically, when the signal retransmission unit **113** has received the retransmission request again at a time exceeding the retransmission suspension time period, the retransmission control unit **114** sends a command to restart the retransmission of signal to the signal retransmission unit **113**.

Here, the details of a process of calculating the signal travelling time by the arrival calculation unit **112** will be described. When the transmission signal is transmitted to the communication device B by the transmitting/receiving unit A-**1**, the signal travelling time calculation unit **112** determines whether the transmitted signal is a signal which requests transmitting of a response signal, such as a handshake signal. For example, it is assumed that the transmission signal is a User Data (AMD-PDU) signal specified by 3G communication standard. Then, in a case where a P-bit contained in the User Data (AMD-PDU) signal is set at ON, the signal travelling time calculation unit **112** determines that the signal is a handshake signal. Also, when the transmission signal is a handshake signal, the signal travelling time calculation unit **112** acquires a time at which the transmission signal is transmitted to the communication device B (hereinafter, referred to as appropriately "transmission time").

In the meantime, when the receipt signal is received from the communication device B by the transmitting/receiving unit A-**1**, the signal travelling time calculation unit **112** determines whether the receipt signal is a response signal corresponding to the handshake signal. For example, it is assumed that the receipt signal is a User Data (AMD-PDU) signal specified by 3G communication standard. Then, in a case where 0010 is set in a SUFI TYPE field contained in a Control Data (STATUS-PDU) signal and also a predetermined condition is satisfied, the signal travelling time calculation unit **112** determines that the signal is a response signal corresponding to the handshake signal. Further, the fact that the predetermined condition is satisfied indicates that, for example, SN+1 set in the User Data (AMD-PDU) signal in which the P-bit is set at ON coincides with ACK LSN set in the Control Data (STATUS-PDU) signal. Also, when the receipt signal is the response signal corresponding to the handshake signal, the signal travelling time calculation unit **112** acquires a time (hereinafter, referred to as appropriately "receipt time") at which the receipt signal was received by the transmitting/receiving unit A-**1**. Also, the signal travelling time calculation unit **112** measures a round trip time which is a difference between the transmission time and the receipt time. For example, the signal travelling time calculation unit **112** measures a signal travelling time using the following equation (1)

$$\text{signal travelling time} = \text{round trip time} \times \tfrac{1}{2} \quad (1)$$

Next, a communication state between the communication device A and the communication device B will de described. FIG. **3** is a signal sequence chart illustrating the communication state of a communication device A and a communication device B according to an embodiment in a chronological order. In the example illustrated in FIG. **3**, the communication device A is the base station **30** and the communication device B is the mobile terminal **50**.

First, the communication device A transmits a signal "n" which is a handshake signal to the communication device B (step S**101**). The communication device B that has received the signal "n" transmits a response signal "n" corresponding to the signal "n" to the communication device A (step S**102**). Since the signal "n" is a handshake signal, the signal travelling time calculation unit **112** of the communication device A acquires a transmission time at which the signal "n" is transmitted from the transmitting/receiving unit A-**1** to the communication device B at step S**101**. In the meantime, since the response signal "n" corresponds to the handshake signal, the signal travelling time calculation unit **112** acquires a receipt time at which the response signal "n" is received by the transmitting/receiving unit A-**1** at step S**102**. Then, the signal travelling time calculation unit **112** calculates a round trip time T1 which corresponds to a difference between the transmission time and the receipt time. The signal travelling time calculation unit **112** calculates the signal travelling time T2 using the equation (1) described above. The calculated signal travelling time T2 is held in the signal travelling time calculation unit **112**.

Thereafter, the communication device A transmits signal "a" having a sequence number of 0 (zero) to the communication device B (step S**103**). It is assumed that the signal "a" arrives at the communication device B. Subsequently, the communication device A transmits signal "b" having a sequence number of 1 (one) to the communication device B (step S**104**). It is assumed that the signal "b" does not arrive at the communication device B. Subsequently, the communication device A transmits signal "c" having a sequence number of 2 (two) to the communication device B (step S**105**). It is assumed that the signal "c" arrives at the communication device B. Subsequently, the communication device A transmits signal "d" having a sequence number of 3 (three) to the communication device B (step S**106**). It is assumed that the signal "d" does not arrive at the communication device B. Subsequently, the communication device A transmits signal "e" having a sequence number of 4 (four) to the communication device B (step S**107**). It is assumed that the signal "e" arrives at the communication device B.

In the meantime, the communication device B which has received the signal "c" detects that the signal "b" is missed and transmits a retransmission request of the signal "b" to the communication device A (step S**108**). The communication device B which has received the signal "e" has not yet received the signal "b" and the signal "d". Therefore, the communication device B detects that the signal "b" and signal "d" are missed and transmits the retransmission request of the signal "b" and a retransmission request of the signal "d" to the communication device A (step S**109**).

Further, as for a method for detecting the signal missing in the communication device B, for example, when a signal is received, a retransmission request may be sent for one or more signals not yet received among signals to be received earlier than the received signal. This eliminates the need for storing information on the transmitting of the retransmission request.

The communication device A which has received the retransmission request "b" transmitted at step S**108** retransmits the signal "b" to the communication device B (step S**110**). It is assumed that the signal "b" arrives at the communication device B. The communication device B which has received the signal "b" has not yet received the signal "d". Therefore, the communication device B detects that the signal "d" is missed and transmits the retransmission request of the signal "d" to the communication device A (step S**111**). At step S**110**, when the signal "b" is retransmitted from the signal retransmission unit **113**, the retransmission control unit **114** of the communication device A accesses the signal travelling time calculation unit **112** to read the signal travelling time T2. The retransmission control unit **114** adds the signal travelling time T2 read and the time tb at which the signal "b" was retransmitted from the signal retransmission unit **113** to obtain a retransmission suspension time period Tb for the signal "b", which is a time period from the time tb at which the

communication device A retransmitted the signal "b" to the communication device B, to a time at which the signal travelling time T2 elapses from the time tb.

In the meantime, the communication device A, which has received the retransmission request of the signal "b" and the retransmission request of the signal "d" transmitted at step S**109**, retransmits the signal "d" to the communication device B while suspending retransmission of the signal "b" (step S**112**). It is assumed that the signal "d" arrives at the communication device B. When the signal "d" is retransmitted from the signal retransmission unit **113** at step S**112**, the retransmission control unit **114** of the communication device A accesses the signal travelling time calculation unit **112** to read the signal travelling time T2. The retransmission control unit **114** adds the signal travelling time T2 read and the time td at which the signal "d" was retransmitted from the signal retransmission unit **113** to obtain a retransmission suspension time period Td for the signal "d", which is a time period from the time td at which the communication device A retransmitted the signal "d" to the communication device B, to a time at which the signal travelling time T2 elapses from the time td. In the meantime, since the current time at which the retransmission request "b" is again received by the signal retransmission unit **113** does not exceed the retransmission suspension time period Tb of the signal "b", the retransmission control unit **114** of the communication device A sends a command to suspend the retransmission of the signal "b" to the signal retransmission unit **113**. That is, since the retransmission control unit **114** of the communication device A has received the retransmission request from the signal retransmission unit **113** within the retransmission suspension time period Tb, the retransmission control unit **114** of the communication device A does not retransmit the signal "b".

Assuming that the signal retransmission unit retransmits signals for all of the received retransmission requests, since the retransmission request "b" is received again at the signal retransmission unit even when the signal "b" retransmitted first has arrived at the communication device B, the communication device A retransmits the signal "b" (see the dotted line v in FIG. **3**). However, according to the embodiment, the retransmission of the signal "b" is suspended during the retransmission suspension time period Tb. Accordingly, even if the communication device A has received the retransmission request "b" again after retransmitting the signal "b" to the communication device B, when the current time at which the retransmission request "b" is again received does not exceed the retransmission suspension time period Tb of the signal "b", the retransmission control unit **114** of the communication device A does not retransmit the signal "b".

In the meantime, the communication device A that has received the retransmission request "d" transmitted at step S**111** suspends the retransmission of the signal "d". Since the current time at which the retransmission request "b" received again by the signal retransmission unit **113** does not exceed the retransmission suspension time period Td of the signal "d", the retransmission control unit of the communication device A sends a command to suspend the retransmission of the signal "d" to the signal retransmission unit **113**. That is, since the retransmission request "d" is received again at the signal retransmission unit **113** within the retransmission suspension time period Td, the retransmission control unit **114** of the communication device A does not retransmit the signal "d".

Assuming that the signal retransmission unit retransmits signals for all of the received retransmission requests, since the retransmission request "d" is received again at the signal retransmission unit even when the signal "d" retransmitted first has arrived at the communication device B, the communication device A retransmits the signal "d" (see the dotted line w in FIG. **3**). However, according to the embodiment, the retransmission of the signal "d" is suspended within the retransmission suspension time period Td. Accordingly, even if the communication device A receives the retransmission request of the signal "b" again after retransmitting the signal "b" to the communication device B, when the current time at which the retransmission request of the signal "d" is again received does not exceed the retransmission suspension time period Td of the signal "d", the retransmission control unit **114** of the communication device A does not retransmit the signal "d".

Next, a processing sequence of the communication device A according to the present embodiment will be described. FIGS. **4**A and **4**B are operational flowcharts illustrating a processing sequence of calculating a signal travelling time by the communication device according to an embodiment.

As illustrated in FIG. **4**A, when a transmission signal transmitted from the transmitting/receiving unit A-**1** is not present (No in step S**121**), the signal travelling time calculation unit **112** of the communication device A causes the process to return to step S**121**. When a transmission signal transmitted from the transmitting/receiving unit A-**1** to the communication device A is present (Yes in step S**121**), the signal travelling time calculation unit **112** determines whether the transmission signal is a handshake signal (step S**122**). When it is determined that the transmission signal is not a handshake signal (No in step S**122**), the signal travelling time calculation unit **112** causes the process to end.

In the meantime, when it is determined that the transmission signal is a handshake signal (Yes in step S**122**), the signal travelling time calculation unit **112** acquires a transmission time at which a transmission signal is transmitted to the communication device B (step S**123**), and causes the process to end.

As illustrated in FIG. **4**B, when a receipt signal received by the transmitting/receiving unit A-**1** from the communication device B is not present (No in step S**131**), the signal travelling time calculation unit **112** causes the process to return to step S**131**. In the meantime, when a receipt signal received by the transmitting/receiving unit A-**1** from the communication device B is present (Yes in step S**131**), the signal travelling time calculation unit **112** determines whether the transmission signal is a response signal corresponding to the handshake signal (step S**132**). When it is determined that the receipt signal is not the response signal corresponding to the handshake signal (No in step S**132**), the signal travelling time calculation unit **112** causes the process to end.

In the meantime, when it is determined that the transmission signal is a response signal corresponding to the handshake signal (Yes in step S**132**), the signal travelling time calculation unit **112** acquires a receipt time at which a receipt signal is received from the communication device B (step S**133**). Also, the signal travelling time calculation unit **112** measures a round-trip time which is a difference between the transmission time acquired at step S**123** and the receipt time acquired at step S**133** (step S**134**). Also, the signal travelling time calculation unit **112** calculates a signal travelling time based on the round-trip time (step S**135**), and causes the process to end. Further, the signal travelling time calculated by the signal travelling time calculation unit **112** is held in the signal travelling time calculation unit **112** until the signal travelling time is calculated at next time.

Next, a processing sequence of retransmitting of a signal by the communication device A according to an embodiment will be described. FIG. **5** is an operational flowchart illustrat-

ing a processing sequence of retransmitting of signal by a communication device according to an embodiment.

As illustrated in FIG. **5**, when the retransmission request from the communication device B is not received at the signal retransmission unit **113** (No in step S**141**), the retransmission control unit **114** of the communication device A causes the process to return to step S**141**. In the meantime, when the retransmission request from the communication device B is received at the signal retransmission unit **113** (Yes in step S**141**), the retransmission control unit **114** determines whether the signal corresponding to the sequence number specified by the retransmission request has been retransmitted from the signal retransmission unit **113** (step S**142**).

When it is determined that the signal has not been retransmitted from the signal retransmission unit **113** (No in step S**142**), the retransmission control unit **114** causes the signal to be retransmitted through the signal retransmission unit **113** (step S**143**), and performs computing of a retransmission suspension time period (step S**144**). The computing of retransmission suspension time period is a processing for obtaining a retransmission suspension time period during which retransmission of signal is to be suspended. The details of computing of retransmission suspension time limit will be described with reference to FIG. **6** hereinbelow.

In the meantime, when it is determined that the signal has been retransmitted already from the signal retransmission unit **113**, that is, the retransmission request from the communication device B is received again at the signal retransmission unit **113***b* (Yes in step S**142**), the retransmission control unit **114** performs the following processing. That is, the retransmission control unit **114** acquires the current time at which the retransmission request is received again (step S**145**). Subsequently, the retransmission control unit **114** determines whether the current time at which the retransmission request is again received exceeds the retransmission suspension time period (step S**146**).

When it is determined that the current time at which the retransmission request is again received does not exceed the retransmission suspension time period (No in step S**146**), the retransmission control unit **114** sends a command to suspend the retransmission of signal to the signal retransmission unit **113** (step S**147**), and causes the process to end.

In the meantime, when it is determined that the current time at which the retransmission request is again received exceeds the retransmission suspension time period (Yes in step S**146**), the retransmission control unit **114** sends a command to restart the retransmission of signal to the signal retransmission unit **113** (step S**148**), and causes the process to proceed to step S**143**. At step S**143**, the retransmission control unit **114** causes the signal to be retransmitted through the signal retransmission unit **113**. At step S**144**, the retransmission control unit **114** performs the computing of the retransmission suspension time period and updates the retransmission suspension time period held. According to this, a period of time between a first time at which the signal was retransmitted from the signal retransmission unit **113** for the last time and a second time at which the signal travelling time has elapsed from the first time is newly obtained as the retransmission suspension time period.

Next, the details of the computing of the retransmission suspension time period will be described. FIG. **6** is an example of an operational flowchart illustrating a processing sequence of computing a retransmission suspension time period. The processing sequence illustrated in FIG. **6** corresponds to step S**144** of FIG. **5**.

As illustrated in FIG. **6**, when the signal is retransmitted from the signal retransmission unit **113** at step S**143**, the retransmission control unit **114** accesses the signal travelling time calculation unit **112** to read a signal travelling time (step S**151**). Subsequently, the retransmission control unit **114** adds the signal travelling time read to a first time at which the signal is retransmitted from the signal retransmission unit **113** at step S**143**, to obtain a second time at which the signal travelling time elapses from the first time, thereby obtaining the retransmission suspension time period from the first time to the second time, during which the retransmission of the signal is to be suspended (step S**152**), and causes the process to end.

As described above, the communication device A according to the embodiment calculates a signal travelling time required for a transmitted signal to arrive at the communication device B, and suspends the retransmission of the signal when the retransmission request is received from the communication device B during a time period from a first time at which the signal has been retransmitted lastly, to a second time at which the signal travelling time elapses from the first time. According to this, the communication device A does not perform the retransmission of the signal which may not be performed originally. Accordingly, according to the communication device of the embodiment, it is possible to suppress the increase of an amount of data flowing in a communication path **2** between the communication device A and the communication device B. As a result, it is possible to reduce the communication overhead between the communication device A and the communication device B according to the communication device of the embodiment.

Further, when the retransmission request is received from the communication device B after the signal is retransmitted for the last time and then the signal travelling time has elapsed, the communication device A of the embodiment restarts the retransmission of the signal. According to this, the communication device A is able to perform the retransmission of the signal appropriately for the retransmission request produced from the communication device B due to a non-arrival of the signal retransmitted for the last time at the communication device B. Accordingly, according to the communication device of the embodiment, it is possible to perform the retransmission of the signal which is desirable to be performed originally while suppressing the increase of an amount of data flowing in a communication path **2** between the communication device A and the communication device B. As a result, according to the communication device of the embodiment, it is possible to avoid missing of signal while suppressing the decrease of a communication speed between the communication device A and the communication device B.

Further, the communication device A of the embodiment calculates the signal travelling time based on a round trip time ranging from a time at which the signal is transmitted to the communication device B to a time at which a response signal returned from the communication device B in response to the transmitted signal is received at the communication device A. Accordingly, according to the communication device of the embodiment, it becomes possible to rapidly calculate the signal travelling time with a simple configuration of measuring a round trip time.

Further, in the description described above, an example is illustrated in which the signal travelling time calculation unit **112** of the communication device A calculates the signal travelling time based on the round trip time, but the calculation of the signal travelling time is not limited thereto. For example, the signal travelling time may be determined by

holding a table in which the round trip time is stored in association with the signal travelling time and retrieving the table with the round trip time.

(Hardware Configuration)

Next, a hardware configuration of the communication device A according to the embodiment will be described. FIG. **7** is a diagram illustrating an exemplary hardware configuration of the communication device A. Here, the communication device A is the base station **30**.

As illustrated in FIG. **7**, the communication device A includes a processor **1001**, a ROM (Read Only Memory) **1002**, a memory **1003**, a radio unit **1004**, a network interface **1005**, and an antenna **1006**.

The ROM **1002**, the memory **1003**, the radio unit **1004**, and the network interface **1005** are connected with the processor **1001** through the bus **1007**, respectively.

The network interface **1005** is, for example, an interface for connecting with a higher level device.

The antenna **1006** is connected to the radio unit **1004**. For example, functions of the transmitting/receiving A-**1** illustrated in FIG. **2** are implemented by the radio unit **1004** and the processor **1001**.

The ROM **1002** stores programs used for processing performed by, for example, a control plane unit **110** and a data plane unit **120** stored therein. Also, the processor **1001** reads various programs stored in the ROM **1002**, and deploys the read programs on the memory **1003** to produce and execute a process performing each processing.

For example, the functions described above performed by the control plane unit **110** and the data plane unit **120** illustrated in FIG. **2** are implemented by the processor **1001**, the ROM **1002**, and the memory **1003**.

A hardware configuration of the communication device B according to the present embodiment will be described. FIG. **8** is a diagram illustrating an exemplary hardware configuration of the communication device B. Here, the communication device B is the mobile terminal **50**.

As illustrated in FIG. **8**, the communication device B includes a processor **2001**, a ROM **2002**, a memory **2003**, a radio unit **2004**, a display unit **2005**, an input unit **2006**, a communication interface **2007**, and an antenna **2008**.

The ROM **2002**, the memory **2003**, the radio unit **2004**, the display unit **2005**, the input unit **2006**, and the communication interface **2007** are connected with the processor **2001** through the bus **2009**, respectively.

The display unit **2005** is, for example, a liquid crystal screen. Further, input unit **2006** is, for example, a keypad. An operator of the communication device B inputs various information using the display unit **2005** and the input unit **2006**.

The communication interface **2007** is, for example, a speaker or a microphone. An operator of the communication device B performs operations, such as transmitting and receiving of voice using the communication interface **2007**.

The antenna **2008** is connected to the radio unit **2004**.

The ROM **2002** stores programs for executing processing stored therein. Also, the processor **2001** reads various programs stored in the ROM **2002**, and deploys the read programs on the memory **2003** to produce and execute a process performing each processing.

According to one aspect of the communication device disclosed herein, the communication overhead between the communication devices caused by the retransmission of signal may be reduced.

All examples and conditional language recited herein are intended for pedagogical purposes to aid the reader in understanding the invention and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although the embodiment(s) of the present invention has (have) been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

**1**. A communication device comprising:

a signal retransmission unit configured to retransmit a signal to another communication device serving as a communication partner when a retransmission request of the signal is received after the signal has been transmitted to the another communication device; and

a retransmission control unit configured to suspend a retransmission of the signal when the retransmission request is received again from the another communication device before a signal travelling time elapses from a first time at which the signal has been transmitted from the communication device, the signal travelling time indicating a time period from the first time to a second time at which the transmitted signal is expected to arrive at the another communication device.

**2**. The communication device of claim **1**, wherein

when the retransmission request is received again after the signal travelling time has elapsed from the first time, the retransmission control unit restarts the retransmission of the signal.

**3**. The communication device of claim **1**, further comprising

a signal travelling time calculation unit configured to determine the signal travelling time based on a round-trip time indicating a time period from the first time to a third time at which a response signal returned from the another communication device in response to the signal transmitted from the communication device is received at the communication device.

**4**. A communication method performed by a communication device, the communication method comprising:

calculating a signal travelling time indicating a time period from a first time at which a signal is transmitted from the communication device to a second time at which the transmitted signal is expected to arrive at another communication device serving as a communication partner;

retransmitting the signal to the another communication device when a retransmission request of the signal is received from the another communication device after the signal has been transmitted to the another communication device; and

suspending a retransmission of the signal when the retransmission request is received again from the another communication device before the signal travelling time elapses from the first time.

**5**. The communication method of claim **4**, further comprising

restarting the retransmission of the signal when the retransmission request is received again from the another communication device after the signal travelling time has elapsed from the first time.

**6**. The communication method of claim **4**, wherein

the signal travelling time is determined based on a round-trip time indicating a time period from the first time to a third time at which a response signal returned from the another communication device in response to the signal

transmitted from the communication device is received at the communication device.

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